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AN EVALUATION OF THE POTENTIAL FOR WHEY CHEESE PRODUCTS IN CANADA

by

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ABSTRACT

An investigation of various means of processing whey which might be applicable to small cheese factories was carried out.

Whey cheese, which is very popular in Scandinavian countries, was found to be a good possibility. It is made by condensing sweet whey and a milk/cream mixture.

An evaluation of the market potential for whey cheese in Canada was made in a consumer survey of 560 Edmonton households.

Although the acceptability of the products was found to be somewhat limited, the response was sufficiently encouraging for further product development work to be carried out.

A new spread product was made from cottage cheese whey, rather than cheddar cheese whey since this type of whey is more difficult to utilise, and is presently being disposed of in the Edmonton area. Consequently it was necessary to neutralise the whey due to the effect of the acid nature of the whey on flavour.

Trials with various formulations which had a range of solids contents (60-70%) and fat contents (5-20%), made by further condensing of condensed cottage cheese whey (neutralised to pH 5.0-6.0) and butteroil, led to the conclusion that the best composition was 70% solids, 20% fat and pH 6.0. This formulation resulted in a product which usually had a smooth texture with no detectable lactose crystals present, a good, spreadable consistency, a fairly bland creamy flavour and cream colour.

Two flavoured prototype products (i) an onion-flavoured spread for crackers and (ii) a sweetened maple-flavoured breakfast spread were found to be acceptable by a small consumer panel.

A product from lactose-hydrolysed whey had a soft texture and interesting caramel flavour and colour, but still had a problem of sandiness in texture.

Some further work is still required for some aspects of the process e.g. to overcome the problem of sandiness in the products and in scaling up the process.

However, these products may be a promising alternative means of whey utilisation particularly for the smaller processor.

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INTRODUCTION

A. Problems of Whey Disposal

The disposal of whey in the present-day dairy industry has become of concern for a number of reasons. One of the major factors is that whey disposal causes what is considered to be a heavy load of pollution in these ecologically - conscious times. As well as being a pollution problem, whey disposal represents an economic loss, since it is a potentially useful and commercially valuable source of lactose and protein in particular. In addition, it is also a loss of valuable nutrients. The main problems of profitably utilising whey are its bulkiness, low content of valuable solids and high cost of transporting whey from cheese factories to a processing plant.

B. Whey Disposal and Utilisation

1. Situation in Canada

The situation regarding the amount of whey being produced, its geographical location and the present means of disposal and utilisation in Canada was ascertained in a 1972 survey of cheese factories which is summarized in Table 1. Disposal consists of whey being run into the sewer or waste disposal system, being sprayed on fields (where it can be of benefit as a fertiliser if prudently applied), or disposed of into quarries, streams and ditches.

The proportion disposed of into the sewer decreases with plant size, but however the proportion being disposed of into quarries, streams, and ditches increases. For example, plants with whey production less than 5 million lb/year dispose of 56.7% of their whey into the sewer or waste

Table 1

Method of Disposal and Utilisation of Whey According to Plant Classification *

Plant classification '000,000 lb/yr		A (<5)	B (5-10)	C (10-25)	D (25-50)	E (50-100)	F (>100)	% total whey prodn.
No. of plants		90	28	38	14	7	5	
% of total plants		49.5	15.4	20.9	7.7	3.8	2.7	
% of whey prodn.		7.6	7.4	21.5	19.3	18.5	25.7	
** Annual whey prodn. '000 lb		197,129	191,978	560,557	501,085	482,430	669,800	
% Disposed (43.3%)	Sewer or waste disposal	56.7	26.7	27.3	15.8	10.8	-	17.2
	Spray on fields	9.5	25.9	26.3	17.1	-	-	20.9
	Quarries, streams and ditches	12.7	15.9	15.5	23.4	24.7	-	8.7
** Amount of whey '000 lb		155,402	131,473	386,865	282,290	171,080	-	
% Utilised (56.7%)	Fed to animals	16.3	22.9	13.4	8.7	2.2	-	7.8
	Sell to processor	4.8	4.3	5.9	24.0	31.4	10.9	15.7
	Dry pure whey	-	4.5	9.4	11.0	30.9	85.7	32
	Mix with skimmilk or feed and dry	-	-	2.1	-	-	3.4	1
	Other	-	-	0.2	-	-	-	neg
** Amount of whey '000 lb		41,727	60,505	173,692	218,795	311,350	669,800	

* Summarised from: Modler et al (1973).

** Total production for all factories within each class.

disposal system whereas the second largest plants with between 50-100 million lb/year whey production dispose of only 15.8% in this manner. The largest size factories report that they utilised all of their whey i.e. there was no disposal of whey.

Overall, it is the moderate sized plants which are disposing of the greatest quantities of whey. In fact, 85% of the unprocessed whey comes from plants with an approximate daily production of 200,000 lb. whey or less.

Utilisation consists of feeding to animals (usually to hogs), selling to a processor, drying (either roller or spray drying) or mixing with skim milk or feed and drying. The amount dried increases with increasing plant size since these have the capital and/or equipment and quantity of whey to justify the expenditure of drying. Note that the proportions fed to animals decreases markedly with increase in plant size.

The cheese producers surveyed, favoured the setting up of centralised processing factories, and felt that the whey should be dried and subsidised by the Government, or alternatively the price incorporated into that of cheese and the whey powder given away. Centralised processing facilities may be feasible in Ontario and Quebec, but the rest of the cheese plants in Canada appear to be scattered in terms of a possible central processing plant. The cheese producers also suggested the establishment of co-operative hog-feeding enterprises.

2. World Situation

An IDF survey on whey processing, and utilisation (covering only some cheese-producing countries), carried out in 1972 (Emmons et al, 1974), showed that several other countries had a similar situation to

Canada in that a large proportion of whey is wasted e.g. Australia 58%, New Zealand 45%, Spain 33%, South Africa 22%, and Israel 84% c.f. Canada 43%. Among those European countries which process whey by drying, most of it is being utilised as animal feed rather than in human foods. One of the conclusions from this survey was that there is unlimited potential for the use of whey as an animal feed in terms of price and feed energy. The feed energy of 1.1 billion lbs of whey is equivalent to only 1% of the feed energy required to market Canada's 10 million hogs. It was felt that the same was not true for other markets in human food for whey such as lactose and whey powder.

There are two factors which may improve the favourability of processing whey, and in particular for human food use. These are,
(i) with legislation favouring penalties for whey disposal, relative costs will move in favour of utilisation, and
(ii) with the increasing rationalisation of the dairy industry to fewer and larger dairy factories it is no longer economical to ship whey back to the farmers for hog feeding as it is very costly to transport over the longer distances.

3. Situation in Alberta

Whey production in Alberta in 1977 was about 145,500,000 lb, with 112,000,000 lb coming from cheddar and variety cheese production and 33,500,000 lb from cottage cheese manufacture (Lowrie, 1978). A high proportion of the cheese whey produced in Alberta was concentrated in 7 plants in the Northern Alberta (Edmonton, Wetaskiwin) area, where about 74,000,000 lbs. of cheddar and variety cheese whey and 26,000,000 lb of cottage cheese whey were produced.

Some of the whey from the outlying dairy factories in Northern

Alberta is presently being sold to hog-producers, but little processing of whey is being carried out. A great deal of the whey is currently being wasted which is the case for the cottage cheese whey from plants situated in Edmonton. Individually these plants are very small and even were all the whey to be pooled, it may still be difficult to find economical means of utilisation of the whey.

This work is concerned with whey utilisation methods which might be applicable to the situation in Alberta where there are many scattered small plants.

CHAPTER II

LITERATURE REVIEW

A. CURRENT AND POTENTIAL METHODS OF WHEY PROCESSING

A brief review of major whey processing methods and some potential new processes, in relation to their suitability for small plants, follows. Details of patents related to whey processing are covered by Gillies (1974) and summarized by Oborn (1968)and others.

1. Roller Drying and Spray Drying

The product from roller drying of whey is a coloured, often hygroscopic powder, which is usually sold to feed manufacturers for blending into animal or poultry feeds, but it is unacceptable for processing to human food. It is possible that this process could be a reasonably convenient and economic method of whey disposal for a smaller factory. Spray-drying produces a lighter coloured, more soluble powder, which therefore has more functionality in food formulations. It has found uses in the baking industry where it can contribute to the nutritive value, and to qualities of shelf-life, appearance and texture, as well as to the economics of the process. It is being incorporated into ice-cream (skim milk replacement), icings and frostings, dry mixes, battermix, processed cheese, confections, frozen desserts (whipping and gelforming properties) whey-soy beverages and soups. The minimum economic throughput is estimated to be in the region of 200,000 lbs whey/day. Investment required for spray-drying plants is very large and the fixed operation costs are also high (Oborn, 1968).

2. Concentrating by Evaporation

Concentrated whey at 35-60% solids is used in processed cheese foods and sweetened condensed whey (38% whey solids and 38% sucrose) is used in

candy formulations and whips. The same considerations in regard to economics of the process apply as for spray-dried whey powder as smaller factories would find it hard to compete without a guaranteed market and a guaranteed price (Oborn, 1968).

3. Fractionation Techniques

Ultrafiltration and Reverse Osmosis - The process of ultrafiltration uses membrane filtration operating at around 50 psi to produce a protein-rich fraction (protein concentrate), and a fraction containing the balance of the whey solids - lactose, salts and acid. The former portion can be used in food formulations, whereas the latter fraction still represents a disposal problem, though research on fermentation or enzymatic modification of the lactose in the permeate is being carried out, or else the permeate can be treated by reverse osmosis to produce lactose concentrate, from which lactose may be crystallised, and a low B.O.D. permeate (Gillies, 1974 p.41).

Reverse osmosis is a concentration process using membranes with a smaller pore size and much higher pressure (> 200 psi), so that it is possible to concentrate whey to over 40% solids and reduce the ash and lactic acid to a fraction of their initial concentrations. The concentrated whey is either evaporated and spray-dried for use in human food as mentioned above, roller-dried for animal feed or it may be concentrated to 20% solids for transportation to a central processing plant. There is an approximately 90% reduction in the B.O.D. The process may be suitable to smaller plants as it is claimed that the operating and capital costs should be low (Oborn, 1968).

Polyphosphate Precipitation of Whey Protein - At pH 5 or lower, the protein molecules form a complex with the anionic hexametaphosphate and are removed by centrifugation. The protein enriched fraction can be dried, or treated for phosphate removal if a higher protein content is required, then

dried (Modler, 1974). Chemicals such as $AlCl_3$, $FeCl_3$ or $Ca(OH)_2$ have also been used as precipitants.

Electrodialysis - Up to 90% of the minerals can be removed from whey through the process of electrodialysis in which alternate layers of cationic and anionic membranes are permeated by the respective ions under the influence of a small electric potential. This aids in producing a whey powder with a controlled mineral content for special diets, as the basis for a substitute for human milk (for infant feeding), a whey powder of somewhat higher protein content, and removal of any additional minerals which may have been added during processing (Modler, 1974).

Ion Exchange - This is a more efficient method of demineralization. A highly acidic cation exchanger followed by an alkaline resin or a combination of the two exchangers into a mixed bed resin works effectively. However, this process does not appear to be used in North America to any great extent due to technological problems and high production costs (Modler, 1974).

Gel Filtration - Gel filtration is a means of separation based on molecular size. The gel or beads contain openings of such a size that the smaller particles (eg. lactose, salts) permeate the beads while the larger molecules (protein) stay in the mobile phase and are eluted first. This is essentially a batch process, generally treating whey which has been filtered, concentrated and delactosed. A high protein content powder can be prepared which still retains good functional properties (Oborn, 1968).

In general all of these processes could only be considered if a special quality of concentrate were required for direct incorporation into a food product as the cost of drying is prohibitive for small plants.

4. Lactose Production

The technology of lactose production is well established (Webb, et al,1974)

but economical manufacture requires large amounts of whey. Use of lactose in the food industry is rather limited - it is used largely in the pharmaceutical industry.

5. Heat/Acid Precipitated Whey Protein

Commercial processes are used in New Zealand and elsewhere for heat/acid coagulation of whey protein (Oborn, 1968), by heating whey near boiling at pH 6.2-6.5, adjusting the pH to 4.1-4.8, holding for about 30 minutes and then passing through a desludging centrifuge or a filter. The solids from this operation contain about 70% of the denatured protein and their recovery results in a 28% reduction of the B.O.D. of the effluent. This process would ideally be carried out on whey prior to lactose recovery. It could be applicable to a smaller plant, particularly if drying did not need to be carried out. The whey protein finds uses in fortification of foods eg. pasta (Sinnamon, 1974) where its enhancement of the nutritional value is the important factor, or it may be used as a base for a chip dip (True and Patel, 1973) or as a meat extender (Jelen and McIntyre, 1977).

6. Fermentation

Yeast and Yeast/Whey Powders - Whey due to its high lactose content makes it an ideal substrate for growing yeasts (usually Saccharomyces fragilis). The 'Wheast' process is a batch fermentation in which the yeast is recovered as a high grade animal and poultry feed. The effluent stream still contains quantities of soluble matter. The S.A.V. process developed in France involves a double fermentation process followed by evaporation and spray drying. There is no liquid effluent for disposal. The process involves high capital cost and therefore would probably not be suitable for smaller plants (Oborn, 1968).

Ethanol and Lactic Acid - Alternative processes are now available to

produce these products more cheaply from other sources than whey. For example, ethanol is now synthesised from petrochemicals and molasses is the substrate preferred for the production of lactic acid (Oborn, 1968).

7. Alcoholic and Non-Alcoholic Beverages

Various whey beverages have achieved success in Europe eg. Rivella, a sparkling, deproteinized herb-flavoured, fermented beverage from Switzerland, whey champagne and Kwas from Poland and Bodrost from the USSR (See Table 2).

Table 2

Commercially Produced Carbonated Beverages from Whey

Brand	Year Marketed	Country of Origin	Type
Rivella	1952	Switzerland	Non-alcoholic Herbs
Whey Champagne	1966	Poland	Alcoholic Wine-like
Whey Kwas	1966	Poland	Alcoholic Kefir-like
Bodrost	1969	Russia	Alcoholic Beer-like
Tai	1971	Brazil	Non-alcoholic Citrus

From: Holsinger, (1972).

Recent research efforts in North America have been directed toward utilizing whole whey in the form of nutritious whey beverages, both carbonated and non-carbonated (See Table 3).

Table 3

Recent Research Toward Producing Nutritious Whey Beverages

Beverage Use	Formulation		Protein (%)
Snack beverage	Acid whey powder or Fluid acid or Sweet whey	Fruit juice or Fruit juice concentrated (orange)	0.5-1.0
Imitation milk	Fluid acid or Sweet whey	Vegetable hydro-colloids + Vegetable oils	1.0-1.5
Liquid breakfast	Fluid acid or Sweet whey	Soybean powder + Citrus flavouring	2.5-3.5

From: Holsinger, 1972 (loc. cit.)

According to Holsinger (1972), the feasibility of U.S. production and marketing of fortified soft drinks will depend on the production of concentrated undenatured proteins at a reasonable price. The production of a herb-flavoured carbonated beverage similar to Rivella using the permeate from the ultrafiltration of cottage cheese whey, is a promising possibility.

A further recent product 'lactofruit' developed in Switzerland (Fresnel, 1978) is based on hydrolysed lactose syrup. This syrup can be used as a base for several beverage types including low calorie and highly nutritious drinks (by adding whey or milk proteins), either in a single flavor or without carbonation, or be fermented to obtain flavour, carbonation or low alcohol content. The 'lactofruit' itself is a non-fermented nutritious soft drink produced in a clear yellow-coloured liquid form flavoured with tropical fruit or coconut extract.

Production of whey wine has been investigated at Oregon State University and subsequently by Foremost Foods Co. Methods have been developed to process whey into (1) a lightly carbonated, flavoured alcoholic beverage (2) a high-protein material equivalent to current commercial products. A significantly lower market price for whey wine compared to commercial flavoured wines is predicted (Palmer and Marquadt, 1978).

8. Whey Cheeses

Ricotta Cheese - This is basically a heat-coagulated whey protein, made from whey to which a small proportion (5-10%) of whole or skimmed milk is added. Ricotta cheese is popular in Italy - it is suitable for direct eating, the cooking of lasagna and ravioli fillings and for making cream whipped desserts, pancake fillings or cheesecakes. Whey is heated to 85-90°C in a cheese vat by steam jacket or injection of steam. Acidification by sour whey or milk, or 10% solutions of lactic, acetic or citric acid is carried out. The precipitated protein entangles with the approximately 0.25% fat and rises to the surface and is allowed to stand for a short time. It is scooped off by perforated ladles or dippers and filled into perforated molds and allowed to stand several hours in a chilled atmosphere. Depending on the type of cheese (dryness) required, the ricotta may be further pressed.

In a study conducted by True and Patel (1973), ricotta cheese from cheddar and edam cheese whey was flavoured with e.g. blue cheese and green onion flavours, as a low-calorie high protein dip. They suggested it could compete very economically with similar products now available.

Condensed Whey Cheese (Mysost) - Mysost is popular in Scandinavian countries, where it is eaten thinly sliced on bread for breakfast, or as a snack. It is produced by condensing whey with the possible addition of milk

or cream and sometimes added sugar, followed by constant stirring during cooling to prevent the formation of large lactose crystals. The product is brown or tan in colour with a smooth somewhat sticky, plastic consistency and sweet, slightly acid, caramel flavour (Davis, 1976).

Mysost is not strictly a cheese, if cheese is considered as a product made from pressed curds. It does not undergo ripening and has a very good keeping quality on account of the low moisture content - usually 13-18%.

B. POTENTIAL FOR CONDENSED WHEY CHEESE PRODUCTION IN ALBERTA

Most of the processes described in the previous section, require the installation of specialised equipment at a cost which is often prohibitive to the small cheese producer. These processes would require that individual factories co-operate in some whey-pooling scheme and operate a central whey-processing facility. From experience of such operations in the U.S.A., it has been found that the maximum distance over which it pays to transport raw whey is 50 miles (Oborn, 1968). Concentration of the whey, of course, would directly improve these transport costs.

The pooled production of cheese whey in the Edmonton area is around 26,000,000 lb whey/year, and even this is too small an amount for most of the processes described, to be economical. Those processes which might be suitable for such a small-scale operation are roller-dried whey, concentration by evaporation, whey cheeses, reverse osmosis and possibly beverage production.

A preliminary feasibility study of reverse osmosis and utra-filtration for the Edmonton area (including a 50 mile radius), (Economics Division, Alberta Department of Agriculture, ca. 1973), showed that at that time total revenue would not cover operating costs unless the prices

for whey powder rose to 30¢/lb for individual plants setting up units, and 15¢/lb for establishing a central plant, compared to 11-15¢/lb for food-grade whey powder in Ontario at the time.

A feasibility evaluation (Jelen and LeMaguer, 1976) of roller-drying, evaporation and mysost manufacture for small cheese plants with 6,000-50,000 lb whey/day concluded that whey cheese manufacture is the best economic alternative, especially for plants of small size. In the case of this high-cost food product, where the ingredient cost largely out-weighs the operating cost, the economy of scale is not crucial and even the smallest plant may find this product profitable.

The mysost process utilizes the whole of the whey, substantially reducing the pollution load compared to some of the processes e.g. ricotta cheese manufacture.

Considering the favourable economics of the process, and the reduction in pollution achieved, it was considered that an investigation into the manufacture and market potential of the whey cheese, mysost, was warranted.

C. CONDENSED WHEY CHEESE

1. General Characteristics

Condensed whey cheese (also known as brown cheese or mysost) produced by condensing a mixture of whey and cream or milk, is brown in colour with a smooth creamy but firm consistency and it has the flavour of slightly sweetened cream caramel (Kosikowski,1970).

There are four major types of the traditional hard product sold in Norway, along with some more recently developed spreads. The traditional products differ in the fat content (28-30% in the full-fat products and about 20% or less in the low-fat products), and in the proportion of goat's milk used in the raw material (Table 4). The spreads are of lower solids content, and may have added sugar. Some products are also made in Sweden and Iceland.

The cheese is generally eaten very thinly sliced on crispbreads, crackers or ryebread, either for breakfast or a snack, and is taken on hikes since it is a good source of quick energy due to its high carbohydrate content (Kosikowski, 1970). It is described in the Better Homes and Gardens publication "Cooking with Cheese" (1966), as being an appetiser or dessert cheese.

Since whey cheese contains virtually no casein and retains most of the lactose present in milk, it is quite different in nature than cheddar-type cheese. The texture of whey cheese is smooth and pliable rather than waxy, it has a tan colour rather than yellow or gold, the flavour is caramel-like and quite sweet (as a result of the high lactose content), compared to the acidity and volatile flavourings from microbial action in fermented cheddar cheese. Also, the whey cheese does not have as high a nutritional value as cheddar cheese in regard to protein content (it has approximately 10% protein (Table 4) compared to the 25% protein in cheddar cheese).

Table 4

Composition of Some Norwegian Whey Cheese Products *

Trade Name	Product Class a	% Goat's milk in raw material	Proximate Composition % b			
			Moisture	Fat	Protein	Carbohydrate
Gudbrandalsost	G-35	10	18	30	11	37
Flote mysost	F-33	0	18	28	11	37
Elite prim	spread	0	31	7.5	7.5	50
Gem	spread	0	31	1.0	7.5	56

a-the number in the class symbol denotes minimum fat content in dry matter
b-as declared on the label.

* from Jelen and Buchheim, 1976

However, it is similar in the sense of being ready-to-eat, requires refrigeration and is of dairy origin.

2. Method of Manufacture

The manufacture of whey cheese consists of concentrating sweet whey (from rennet casein,cheddar, swiss or mozzarella production), in combination with the desired amounts of cream and cow's or goat's milk, to 80-84% solids, with the development of a plastic consistency and desired brown colour, followed by agitation on cooling to prevent the development of sandiness (See Fig. 1).

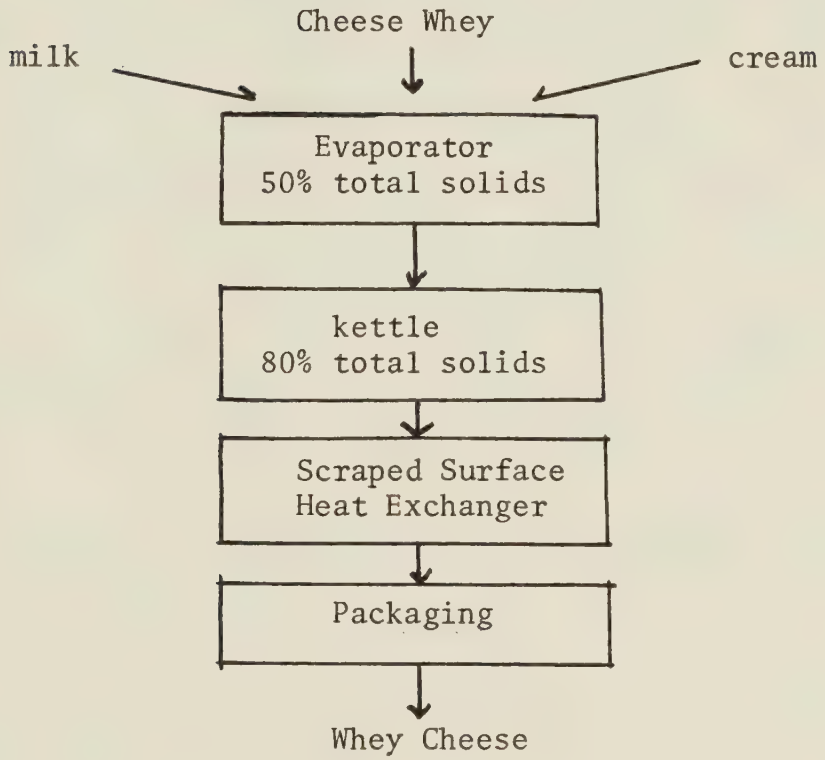
The original process (Frennborn, 1959) consisted of straining sweet whey into an open kettle, constantly stirring over direct heat until the mass had the correct consistency, during which time the brown colour developed, then pouring it into wooden troughs and stirring until cool, to prevent the formation of large lactose crystals.

However, in modern technology (Solberg, 1953), the concentration step usually consists of either: (1) whey being continuously evaporated in a partial vacuum (about 60 ℃) to 50-60% solids and milk and cream added to the concentrate for the final evaporation in a special kettle (Gryta Kettle- a cone-shaped vessel with a scraped surface agitator, and which can be used either under vacuum or pressure). This is carried out under vacuum, with agitation, to 80-84% solids, and then under pressure till the brown colour is formed at 95 ℃, or (2) the mixture of whey, milk and cream is evaporated batchwise in partial vacuum, after a preliminary heating of the milk and cream to 92-95 ℃, with a final evaporation in the Gryta kettle as for (1).

Apparently both continuous and batch methods can be used sucessfully (Bergum and Nilsen, 1950). The former requires separate storage and measuring tanks for the concentrate and analysis of specific gravity and dry

Fig. 1

Production of Whey Cheese



matter content of the concentrate have to be carried out, though this gives better results with regard to plant utilization. No special equipment or analyses are required for the batch method, and it is easier to obtain the correct fat content in dry matter with this method.

A further development (Hansen, 1959) has been the continuous evaporation of the whey/cream mixture, previously preconcentrated to 45% solids, to 80% solids at a temperature of 55-63°C, followed by exposure to steam at 135°C for the desired brown colour to develop.

After concentration, the cheese is then worked or kneaded until cooled to 20-25°C, to prevent the formation of large lactose crystals and therefore sandiness in texture. It is then extruded into foil-lined molds and allowed to set overnight. These two steps are now generally accomplished by a votator-type scraped surface heat exchanger (or OBM cheese-stirring machine), in which the cheese is both cooled with agitation and extruded into the molds thus replacing the batch agitators and mechanical molding equipment which had been developed over the years.

With the use of the Gryta kettle to carry out the final concentration of whey previously evaporated to 65% solids under vacuum, the total cooking time is approximately 106 minutes c.f. 140 minutes when whey is preconcentrated to 40% solids under vacuum and finally concentrated in an open pan, and 150 minutes when the whole of the evaporation is carried out in open pans. Power costs were correspondingly lower, with decreased cooking time (Signerne, 1954)

Further experiments on the equipment (2-stage evaporator and boiling pans) showed an evaporation capacity of 4,120 kg water evaporated per hour and a steam consumption of 0.48 kg per kg water evaporated. The yield of cheese

was 12.1 kg from 100 kg of whey mixture, with consumption of 5.7 kg steam (640 kcal/g), 0.05 Kwh and 0.13 cum water (Sauge, 1960).

Other studies of the technical and economic aspects of the process including yield and labour requirement have been carried out by Byre and Staxrud (1967), Mork et al (1948), Sauge (1961) and Skaltveit and Sorbo (1956).

It has also been found that neutralisation of sour whey with NaOH, improves the texture and flavour of the resulting cheese, providing it is carried out after a preliminary boiling of the whey for 1-1½ hours and after admixture of the milk. Neutralisation to pH 6.8 results in a cheese of pH 5.2-5.4 (Vik and Hedland, 1956).

There does not appear to be much information pertaining to spreads. Presumably the technology is the same, differing only in the ingredients and degree of concentration. However, one product is decribed in Russian literature (Lebedeva and Mironov, 1961) called whey cheese paste, which appears to be similar to whey spreads (Table 5). A mixture of 10 parts of fresh whey acidity <18°T) and 3 parts of skim milk are pasteurised, then with the addition of sugar syrup, pasteurised cream or melted sweetcream unsalted butter, is concentrated under vacuum (60°C) to 65% solids. It is homogenised at 65-70°C at 100 atm, then cooled to 15-20°C and packed in 150 g waxed cartons. The resultant product has a keeping quality of 20 days at a temperature of $\leq$ 5°C.

3. Quality Considerations

The major quality characteristics of whey cheese are the tan colour, caramel flavour and smooth, firm texture. The effect of various factors such as type of whey, pH of whey and % cream/milk mixture used in manufacture, on the chemical and organoleptic quality of whey cheese was examined by Steinsholt et al (1965, 1966), and Steinsholt (1972).

Table 5

Composition of Russian Whey Cheese Paste

	%
Fat	10.0
Fat in dry matter	15.2
Lactose	28-30
Protein	9.0
Moisture	32-35
Sugar	15.0
Other	4.0

Colour - In the traditional whey cheese, the characteristic brown colour is considered desirable. It obviously results from a Maillard browning reaction between lactose and the whey proteins and usually occurs to the greatest extent at temperatures greater than 95°C.

In an investigation of the effect of pH value of the whey and %cream/milk mixture added to the whey, on the chemical and organoleptic quality of cream mysost F33, it was found that the quality score for colour was dependent both on the percentage of nitrogen and % TS in the cheese (Steinsholt et al, 1965). The effect of the nitrogen may be explained by the Maillard theory of browning that proteins or other nitrogen-containing substances are major factors in the development of brown colour in the product. Other components (e.g. lactose) which are part of the total solids may also be important. Maillard browning generally increases with increasing pH in the range of pH 5.0-6.0.

However, apparently those products which do not contain cream are a darker brown colour (Kosikowski, 1970).

Flavour - One of the major factors affecting flavour in whey cheese is acidity. Steinsholt et al (1965) concluded that the acid taste of mysost (which was shown to be highly inversely correlated to the percentage of the cream/milk mixture), is reduced by an increasing percentage of nitrogen. It was also related to the pH value of the whey cheese which is dependent on the pH value of the whey, ash content (which may be related to increasing the amount of precipitated $Ca_3(PO_4)_2$ in the cheese, causing a higher concentration of hydrogen ions), and also on the content of total solids as the content of hydrogen ions in the water phase increases when the water content is decreased. A further study by Steinsholt (1972), on the effect of various factors on the

quality of the G35 type product, concluded that increasing the amount of protein and fat showed a favourable influence upon the flavour of the cheese (confirming the results of the first study with cream mysost F33).

Texture - The major components of texture are firmness and smoothness in texture, with no detectable lactose crystals present.

In the study by Steinsholt et al (1965, 1966), firmness as measured by resistance against pressure at 6°C was found to be dependent on % nitrogen, colour (both these as a result of higher water binding capacity) and % total solids (lower water content means a harder cheese).

On cooling of whey cheese below 93.5°C, the lactose crystallises into the α-hydrate form with tomahawk, and sometimes columnar-shaped crystals. If these are too large, the texture is grainy or sandy. There was a significant correlation between sandiness determined by a scoring panel and the average size of the longest side of the lactose crystals (Steinsholt et al, 1965).

In the hard cheeses, Bergum (1950) considered that if the maximum crystal size was greater than 100μ, sandiness could be detected. In his investigation on the crystallization of lactose in whey cheese, he found that the mean crystal size (size of the longest crystal edge) was between 20-40μ for most of the different kinds of cheese, whereas the maximum crystal size varied from 90μ up to 250μ.

Studies have shown that generally slow cooling and vigorous produced a good product (Frennborn, 1959). In experiments with thorough agitation of the cheese at different temperatures, the mode of cooling

was of less significance in a quickly agitated cheese. The rapid agitation produced a finer and better consistency and sweeter taste than in the control cheese.

Sandiness in whey cheese has been ascribed to either extraordinarily large lactose crystals as previously mentioned or to the agglomeration of lactose crystals (Solberg, 1953). For cheeses with fat contents in dry matter greater than 20%, it was proposed that during evaporation, the lactose solution is the continuous phase wherein the fat and coagulated and uncoagulated proteins are dispersed, but when the whey mixture is adequately concentrated, a reversal of phases is brought about by agitation. The lactose solution is dispersed as larger and smaller drops separated by fat and proteins. One or more lactose crystals may originate in these drops. The more intensified the agitation, the smaller the drops and consequently the smaller the crystals (Solberg, 1953). However, Bergum (1950) found that the mean crystal size in the cheese was the same whether it had been stirred for one or several minutes, and since it was known from experience that unstirred whey cheese paste will be sandy, he concluded that sandiness need not be due to the fact that it contains large crystals but may be due to the agglomeration of the lactose crystals (which a long stirring time seems to prevent).

With the moisture contents in cheese of more than 20-22%, the cheese has to be cooled in a special way or else these smaller drops are apt to run together into larger units. It was these considerations which led to the development of the continuously working agitator for cooling the whey cheeses prior to molding and packing.

In examining Swedish cream whey cheese (10% fat, 33% moisture, 42% lactose), Frennborn (1959) considered that the average crystal size

should be less than 10 μ and that the product had a mealy consistency when the mean crystal size was greater than 30 μ , as is the case in sweetened condensed milk. The average crystal size apparently has to be much smaller in the softer spread products than in the hard cheeses where the limit of detection for sandiness is 100 μ compared to 30 μ in the spread products.

For this product, where the lactose-in-water content is 56%, the temperature 65 °C is in the metastable area between final and supersolubility of lactose (which according to the forced crystallisation curve of Hunziker (1949) is the optimum temperature for maximum velocity of lactose crystallisation), and seeding with small lactose crystals at this temperature will give rapid crystallisation, small crystals and a good consistency. This method , originally developed for the manufacture of sweetened condensed milk was applied to dairies where sandiness in whey cheese had been a problem. The condensed whey solids were cooled to 65-70 °C in wooden troughs and seeded with small lactose crystals in the form of sweetened condensed milk (one 14 oz. tin/50 kg batch). The temperature was held at 65-70°C for about 30 minutes, and the mass stirred continuously. The temperature was then decreased to room temperture and the product packed. This was found to improve the quality substantially - the products had a much smoother texture. (Note that this product was manufactured before the development of the continuous agitator in which case the seeding with lactose crystals does not seem to be neccessary).

The theory of formation of a water-in-oil emulsion, for the hard cheese, as proposed by Bergum (reported by Solberg, 1953), does not seem to be borne out by the structure observed by Jelen and Buchheim (1976), which was not in the form of either a water-in-oil or oil-in-water emulsion, but

was rather a 3-phase system of lactose crystals embedded in free fat, mixed with dispersed areas of aqueous phase containing protein, fat globules, dissolved lactose and minerals. In the spreads there appears to be a continuous aqueous phase containing lactose crystals and small fat globules.

Whatever the mechanism, it is very well established that continuous agitation during cooling results in products with an acceptably smooth texture, and this is an integral part of modern technology.

4. Microbiological and Keeping Quality

At the end of boiling the product is almost sterile, but there is the possibility of recontamination on subsequent handling. The keeping quality of samples of whey cheese held at 17 °C and examined after 14 days, was related to bacteriological content (Oterholm and Sodal, 1959).

On examination of 152 samples of whey spread and cheese with pH 5.4-5.9, Kjell (1955) found that 72% of the samples had less than 100,000 organisms per gram, the yeast count was less than 1000 per gram in 68% of the samples and molds were found in only 6 samples of whey spread.

The a_w of the whey cheeses and spreads ranges from 0.75 to 0.89 (Jelen and Buchheim, 1976), which is inhibitory to the growth of most bacteria, but will allow the growth of molds.

No data on the shelf-life of these products was found in literature, but it is assumed that the shelf-life is a long period of time, especially for the hard cheese. Samples of the cheese used in this study kept for one year quite satisfactorily except for contamination by molds after the opening of the packages.

5. Marketing and Economic Considerations

Sales of Whey Cheeses in Norway

Whey cheeses and spreads currently account for about 34% of the consumption of cheese in Norway (See Table 6). This is somewhat lower than the 50% stated by Kosikowski (1970).

Table 6

Sales of Cheeses in Norway in 1976

	Tonne	% of sales
White cheeses	23,662	57.4
Brown (whey) cheeses and spreads	13,998	33.9
Processed cheese and imported cheese	3,596	8.7

Statistics from Norwegian Dairies Sales Association. Sundt, 1976

The sales of whey products in Norway indicate that the customers tend to prefer the higher quality (in terms of fat and goat's milk content), and therefore the more expensive types of whey cheese (Solberg, 1953). The variety Gudbrandalsost (G-35), which must contain a fat content of at least 35% of the total solids and at least 1 liter of goat's milk per kg of cheese, is the most popular variety.

Potential for Marketing Whey Cheese in Canada

Solberg (1953) expressed the opinion that the possibilities of introducing the best types of Scandanavian cheeses and spreads on the inter-

national market seemed rather limited, although it was possible that they could be manufactured in more countries and were fairly easily transportable. He suggested that with the addition of various substances, the concentrates might be more suited to different tastes and habits.

In fact, at the present time some whey cheeses and spreads are being exported to other countries e.g. in 1976, 1,161 tonne of cheese and spread were exported to European countries, the U.S.A and Canada - about 1/20 of Norway's total cheese exports. Presumably this is being consumed mainly by expatriate Norwegians.

Trends in Consumption of Cheese and Spread Products in Canada

Figures for the consumption of cheeses and spread products (peanut butter, sandwich spreads, jams, jellies and marmalade, and honey) were obtained from Government statistics.

Consumption of cheese in Canada is increasing (See Fig. 2), particularly for varieties other than cheddar.

For spreads however (See Fig. 3), consumption is increasing rapidly only for peanut butter, whilst the trend for sandwich spread is of slightly increasing consumption and for the jams, jellies, marmalade group and honey it is decreasing slightly.

As previously discussed whey cheeses are not at all like cheddar cheese but can be considered a dessert cheese, and might have greater potential sales through marketing efforts at increasing consumer awareness of the product.

The spread is somewhat similar to peanut butter in appearance, but is lower in protein content (10% and 27% respectively), fat content (10% and 50% respectively) and caloric content (290 compared to 580 calories). On the other hand, the product is not as sweet as jams, jellies, marmalade or honey, but does have a higher nutritional value by virtue of its protein content.

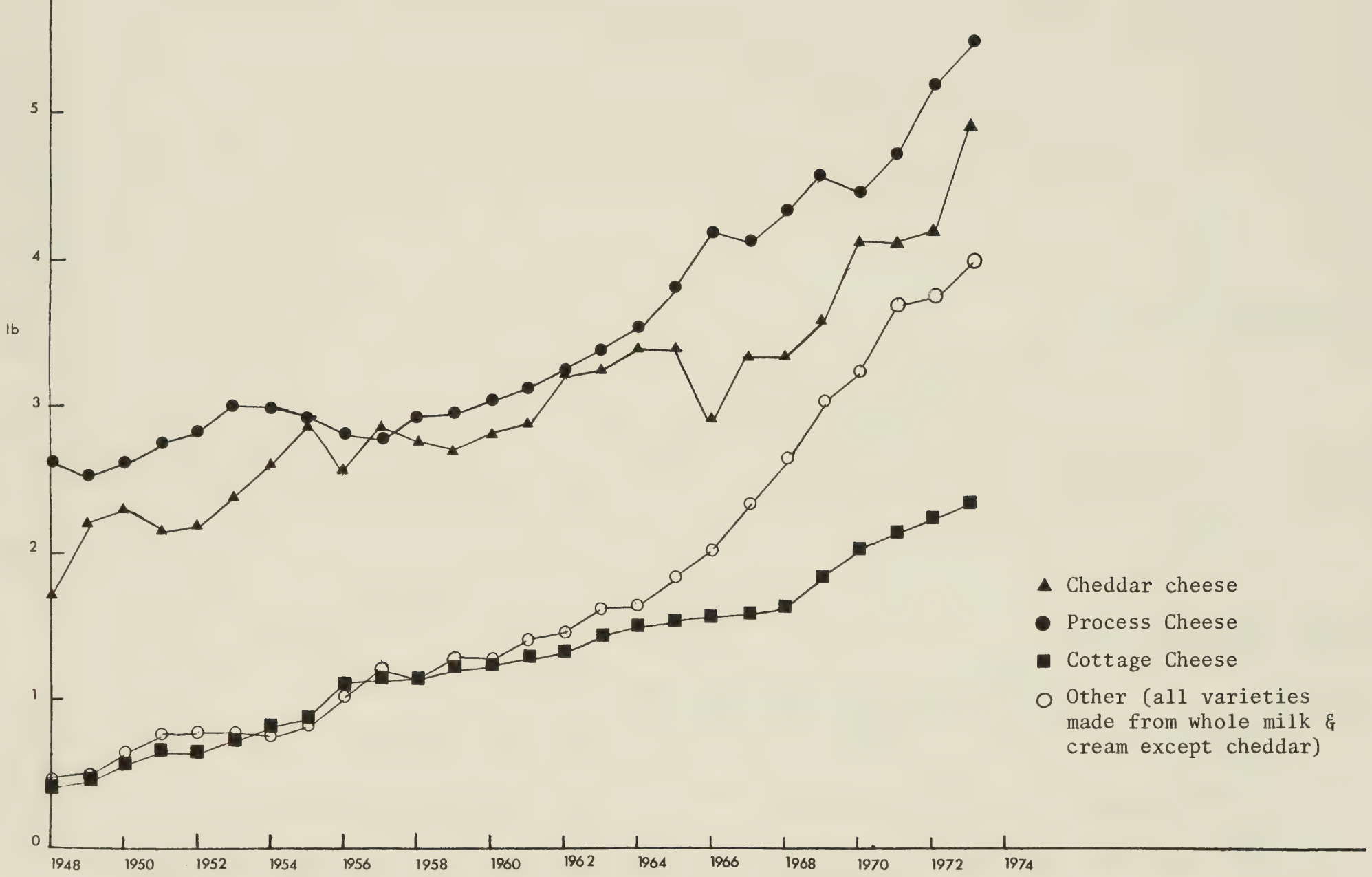


Fig. 2 Consumption Per Capita of Cheese in Canada, 1948-1973

Source: "Handbook of Food Expenditures, Prices and Consumption" Economics Branch Publication 75/6, Agriculture Canada

Fig. 3 Apparent Per Capita Domestic Disappearance[a] or Production[b] of some Spread Products in Canada

Source: Statistics Canada Cat. No. 32-226 and 32-018

Since whey cheese is dissimilar to these more familiar products it is hard to judge the potential for this product unless further information is obtained through various consumer surveys.

CHAPTER III

OBJECTIVE OF THE STUDY

It was decided to investigate the market potential of whey cheese in Canada, because of the advantages of the whey cheese process in terms of its:

a) complete utilization of the whole of the whey

b) relatively simple processing method

c) suitability for a smaller manufacturer.

The objectives were two-fold -- firstly, to carry out a consumer survey, and this secondly to be followed by further product development work if necessary.

A. Consumer Survey

The nature of whey cheese is very different from that of cheddar cheese, and different from any other products presently on the market. Consequently, a vigorous marketing effort would be needed to promote the product in its present form. It was hoped that the survey would give an indication of the acceptability of whey cheese in the solid and spreadable form. Further it was hoped that from the comments by respondents it would be possible to gain some ideas of any modifications which would be needed to improve the acceptability of the products.

B. Product Development

Following the survey it was decided that a spread should be developed, since this was more favourably accepted than the solid. The spread was to be as bland in flavour as possible, so that it could later be flavoured acceptably.

The raw material to be used was cottage cheese or acid whey since this is the type available in the Edmonton area, and is presently being

disposed of into the sewer. Since cottage cheese whey has a higher acidity than cheddar cheese whey this could have an adverse effect on flavour, so neutralization of the whey to reduce the sourness of flavour would be investigated.

The main objective in the development of the spread was to examine a range of total solids contents, fat contents and pH to give a prototype product with a smooth spreadable texture and a bland flavour.

This included the effect of these components on the development of sandiness in the product, because a smooth texture is one of the most important quality factors in a spread. In addition, the use of lactose hydrolysis of the whey in preventing any possible problems with sandiness, as well as a means of sweetening the product, would be examined.

Finally, the prototype product was to be flavoured and subjected to some consumer testing to gauge its overall acceptability.

CHAPTER IV

CONSUMER SURVEY STUDY

A. INTRODUCTION

An initial survey (Jelen and Buchheim, 1976) carried out with 108 students in an introductory Food Science class, gave encouraging results for the acceptability of whey cheese products - over 50% of the students rated a commercially produced Swedish whey cheese and a spread prepared from it in the three "like" categories of a 6-point hedonic rating scale. Consequently it was decided to carry out a larger consumer study with the same variety of whey cheese and spread in the city of Edmonton on a randomly selected sample, to check the results on a more representative section of the population.

B. METHOD

1. Materials - The whey cheese used in the consumer survey was a commercial Swedish variety made from cow's milk whey and cream, with added sugar (See Fig. 4). From analysis, it was found to have the following proximate composition-25% moisture, 10% fat, 10% protein, 50% carbohydrate and 5% ash. The whey cheese was bought at Woodwards Ltd., Edmonton where the product is occasionally available in the cheese section. The spread was prepared by grinding the solid cheese in a meat grinder, and mixing this with the appropriate amount of water in a Hobart mixer to obtain a paste with a smooth, spreadable consistency, and a moisture content of 35%. The solid sample (approximately 2 oz.) was wrapped in aluminium foil and the spread samples were packed in plastic tubs, both appropriately labelled and with instructions to keep the products refrigerated.

Fig. 4 Swedish Whey Cheese Used in Consumer Survey.

2. Consumer Sample Selection

The cluster method of sampling was chosen as being most economical and logistically feasible. A sample size of 600 was arbitrarily selected with allowance for non-response, so that the actual sample would be at least over 200 in size.

The sample of consumers was selected using the Henderson's directory of households for Edmonton - 60 numbers were taken from a random number table, and the addresses corresponding to those particular numbered locations on the same numbered page, were used as starting points for clusters of 10 alternative households.

3. Survey Method and Questionnaire

Samples of both the whey cheese and spread were distributed in person, to the randomly selected households in the city, along with a questionnaire which was to be completed and mailed back in the stamped addressed envelope provided. The questionnaire is attached in Appendix 1. The householders were advised to eat the products thinly sliced or spread on bread, toast or crackers, but they were free to use the samples as they wished.

Householders were asked to report when and how they had tried the products, whether they had tried similar products before, and if they were of Scandinavian ethnic background. They were also asked whether they would buy the products if they were available at a reasonable price. Each individual member of the household was asked to express his or her liking for the product on a 6-point hedonic scale. The products were presented as a new dairy product and spread, rather than cheese products, to avoid comparison with other cheeses because of the difference in nature between them as previously described.

4. Analysis of Results

The results from the survey were analysed at the Computing Services Department at the University of Alberta, using the Statistical Package for the Social Sciences 2nd Edn (1975) for cross-tabulation of results and testing for significance by the chi-square test.
Information obtained in questions asked per household was taken as pertaining to each individual in the household.

C. RESULTS AND DISCUSSION

1. Return from the Survey

Questionnaire forms were received from 186 households, consisting of 1 to 10 individuals, of the 560 households to which samples were finally distributed. This constitutes a 30% return, which although low, is considered satisfactory in most mail-in surveys (Emory, 1976).

2. Acceptance of Whey Cheese and Spread

Opinions of whey cheese and spread (Question 4 - see Appendix 1)

The percentage of respondents (individual members of the household) who found the samples acceptable in varying degrees (i.e. who rated them either "like very much", "like moderately" or "like slightly"),was 35.7% for the cheese and 40.3% for the spread. (See Table 7). Distribution of opinions was bi-modal, with a peak at "like slightly" and a second, larger peak at "dislike very much". The proportions of opinions for the various age-groups also followed this pattern (see Table 8), with no noticeable differences among them, despite the fact that one might have expected a higher proportion of people in the younger age-group to prefer this rather sweet product.

The results were not as favourable as the earlier student survey previously mentioned (Jelen and Buchheim, 1976), where 55% and 75% of the

Table 7

Proportions of Opinions of Whey Cheese and Spread

	% of Opinions					
	like very much	like moderately	like slightly	dislike slightly	dislike moderately	dislike very much
Whey Cheese	6.3	11.9	17.5	14.6	14.3	35.4
Spread	7.4	13.9	19.0	14.8	12.8	32.0

Table 8

Percent Opinions of Whey Cheese and Spread by Age-Groups

(i) Whey Cheese

Age Group	% of opinions					
	like very much	like moderately	like slightly	dislike slightly	dislike moderately	dislike very much
up to 16	6.5	12.0	17.6	9.3	19.4	35.2
17-25	5.1	13.3	16.3	16.3	11.2	37.8
26-40	7.2	11.2	20.8	13.6	20.0	27.2
41-60	6.7	13.5	23.6	14.6	11.2	30.3
over 60	17.1	7.3	14.6	31.7	4.9	24.4

(ii) Spread

Age Group	% of opinions					
	like very much	like moderately	like slightly	dislike slightly	dislike moderately	dislike very much
up to 16	12.0	11.1	14.8	14.8	19.4	27.8
17-25	5.1	14.3	20.4	16.3	9.2	34.7
26-40	4.8	16.9	23.4	13.7	15.3	25.8
41-60	5.6	15.7	23.6	14.6	12.4	28.1
over 60	24.4	7.3	22.0	19.5	4.9	22.0

panelists respectively, rated the solid and spread in one of the three "like" categories and the products were "disliked very much" by less than 10% of the panelists. This probably is because students are more adventurous in their eating habits than the general public, especially in a Food Science class.

Willingness to buy the Products (Question 3) - 34.1 % and 40.7% of respondents (households) respectively said that they would be willing to buy these products (See Table 9). Most of these would buy occasionally, only a very few reported they would buy the products very often, which is what one would expect of this 'specialty item'. This question was used to gain further confirmation of the acceptability of the products, particularly as it was most likely answered by the person in the household who made most decisions about purchases to be made.

Table 9

Percent of Respondents Indicating Willingness to Buy Whey Cheese & Spread

Suggested Frequency of Purchase	% of households	
	Whey Cheese	Spread
Often	3.8	2.7
Sometimes	30.3	38.0
Never	65.9	59.2

3. Factors Influencing the Acceptance of Whey Cheese and Spread

Previous Exposure to Whey Cheese (Question 5) - Those who had tried these or similar products before showed a greater liking for both the solid and the spread than those who had not tried them before (Table 10i) i.e. 72.4% compared to 30.5% for the solid and 69.5% compared to 35.2% for the spread. This was in line with other experiences during this study - whereas people at first did not like the products particularly, they did begin to develop a liking for them after repeated tasting of the products.

Scandinavian ethnic background (Question 6) - Those of Scandinavian ethnic background also indicated a greater liking for the products than the non-Scandinavian respondents e.g. 61.9% compared to 32.4% respectively for the spread (See Table 10 ii). Of course, these two groups overlap a great deal i.e. those of Scandinavian background constitute the larger proportion of those who had tried the products before (i.e. 57.1% compared with only 9.1% of non-Scandinavians).

Preference for Solid or Spreadable Product (Question 4) - Statistical analysis (by the chi-square test) of the proportion of respondents preferring the whey cheese over the spread, showed a significant preference for the spread (Table 11) which confirmed the findings of the earlier student survey of Jelen and Buchheim, (1976).

Table 10

Factors Influencing Acceptance of Whey Cheese and Spread

(i) Previous Exposure to the Product -

	% indicating liking for * sample		% expressing willingness** to buy	
	Whey Cheese	Spread	Whey Cheese	Spread
Previously eaten	72.4	69.5	64.1	66.7
Not previously eaten	30.5	36.2	27.4	35.5

(ii) Scandinavian Ethnic Background -

	% indicating liking for * sample		% expressing ** willingness to buy	
	Whey Cheese	Spread	Whey Cheese	Spread
Scandinavian	61.9	55.5	57.1	47.6
Non-Scandinavian	32.4	38.4	31.3	40.1

* total of the three "like categories.
** total of the 2 categories ('often' and 'sometimes').

Table 11

Percent of Respondents Expressing Preference for Whey Cheese or Spread

Age Group	Prefer Whey Cheese A	Prefer Spread B	No Preference C
Up to 16	13.9	15.7 *	70.4
17-25	13.3	18.4 *	68.4
26-40	18.5	23.4 *	58.1
41-60	10.1	15.7 *	74.2
Over 60	7.3	19.5 *	73.2

* A vs B - significant at $p \leq .001$

4. Manner in Which the Samples were Eaten

(a) Time of Day the Samples were Eaten (Question 1) - Both the solid and the spread were most frequently eaten as a snack (60.2% and 62.8%, respectively) - See Table 12. They were also eaten quite frequently at lunch but the spread was eaten somewhat more often at breakfast. This might be expected because spreads are probably a more common breakfast item than a cheese.

Table-12

Time of Day that Whey Cheese and Spread Samples were Eaten

	% of households	
Time of the day	Solid	Spread
Breakfast	9.3	13.3
Lunch	23.0	17.9
Supper	7.5	6.0
Snack	60.2	62.8

(b) How the Samples were Eaten - (Question 2) -Samples were eaten mostly on crackers (54%) and on bread (approximately 24%)- (See Table 13). The spread was more frequently eaten on toast than the solid, which likely is related to its being more frequently eaten at breakfast. Very few people tried the solid and spread with other foods or in other ways than those suggested.

The overall tendency, then, was for the products to be eaten as a snack on crackers or the spread as a breakfast spread.

Table 13

How Whey Cheese and Spread Samples Were Eaten

Manner of eating	% of households Solid	Spread
On bread	22.8	24.1
On toast	11.6	17.1
On crackers	53.4	54.3
Other	12.2	4.5

5. Comments from Respondents (See Table 14)

There were numerous comments that the products were too sweet, especially by those who considered them to be a type of cheese. Although it was hoped that this comparison could be avoided, it obviously was frequently made. In addition, many people commented on the blandness of flavour, and also on a strong aftertaste or saltiness.

In regard to texture, there were several comments on grittiness, chalkiness, mealiness (these were probably related to the detection of lactose crystals) and stickiness.

Many people found the tan colour to be distasteful.

Quite a number of people likened the product to peanut butter mainly because of its colour and consistency. Others felt that the product was similar to candy and that "children would probably like it".

Some of the respondents felt that the flavour lost its appeal on repeated sampling, but others said that although the product was rather peculiar at first try, they could acquire a taste for it. This has been the experience of quite a number of others associated with the project who have

Table 14

Selected Comments from Whey Cheese and Spread Survey.

Too sweet.

Not bad. Flavour takes time to get used to.

Too salty and fudge-like. Not creamy enough.

Strange combination of flavours.

Sweet and salty. Not too appealing

Would like more definite flavour - you know you're eating something, but aren't quite sure what.

Didn't like the looks mainly.

Found both rather tasteless.

Spread tastes better in mouth than down throat.

Bland and gritty.

Pleasant taste in small amounts, but larger amount were sickening.

We thought the spread had a less chalky texture and was in this respect more appetising than the solid product. Both are too sweet and bland for out tastes - it looks like a cheese and one expects a stronger more tangy flavour. The aftertaste of milk is pleasant. The color isn't particularly attractive - the brown tint makes it look odd. Sorry to be so negative, but we think you'd have to be a starving Scandinavian existing on raw herring to appreciate this food.

Superb.

tried the product.

6. Effectiveness of the Questionnaire -

In trying to avoid the connotation of the samples as cheese products, the product identification and eating instructions were purposely formulated rather vaguely. This turned out to be a disadvantage e.g. although it was suggested that the cheese be thinly sliced, there was no control over the amount consumed or whether it was eaten with bread or crackers, or by itself- factors which could have had quite an effect on acceptability. Indeed, the open-endedness of the questionnaire was not as successful as hoped in finding out what category of foods people associated the products with (in effect the 'consumer concept' of the products), or in obtaining information on other uses for them.

Unfortunately too, the question on ethnic background was asked per household instead of per individual respondent, and thus even where one member of the household was reported as Scandinavian, the others were inferred to be Scandinavian, and consequently the proportion of Scandinavians is higher in this survey than it is overall in Edmonton (11.4% in the sample, compared to 4.8% in Edmonton city, according to 1971 census figures).

7. Supplementary Housewife Taste Panel -

There was no attempt in the questionnaire at determining the relative importance of flavour, colour and texture in influencing the overall acceptability of the products. A subsequent taste panel study was carried out with 10 housewives, to find out which of these factors might be most important in influencing the score for overall judgment for the products.

The taste panel study was carried out informally - two groups of five housewives were interviewed in private homes. The same samples as had been used in the consumer survey were presented to the housewives on crackers.

The housewives were asked to rate the products for appearance, flavour, texture and overall opinion using a 9-point hedonic scale (See Appendix 2). Statistical analysis for regression showed that flavour and texture were significantly correlated with the overall opinion for the whey cheese, whilst only flavour was significantly correlated for the spread (See Table 15). These results seem to indicate that flavour is the most important determining factor for acceptability.

Table 15

Results of Supplementary Housewife Taste Panel

(i) Average Score for Appearance, Flavour Texture and Overall Opinion

	Average Score *			
	Appearance	Flavour	Texture	Overall
Whey Cheese	5.8	6.7	6.1	6.9
Whey Spread	7.0	6.9	7.3	7.6

* 9-point hedonic scale. 9-especially well liked
1-especially disliked.

(ii) Relationship of Score for Appearance, Flavour and Texture to Overall Score

	Correlation Coefficient		
	Appearance vs overall	Flavour vs overall	Texture vs overall
Whey Cheese	.48	.92 *	.81 *
Whey Spread	.29	.67 *	.42

* significant ($p \leq 0.05$) correlation

D. CONCLUSIONS:

The results of the survey showed that the whey cheese and spread were fairly acceptable. The percentage of respondents who liked the products to some degree was 35.7% and 40.3% respectively. This was further confirmed by the fact that 34.1% and 40.7% of households would be willing to buy the products.

The spread was preferred over the solid product, possibly because it was milder in flavour and easier to use.

Previous exposure to the products and Scandinavian ethnic background were related to a higher degree of acceptance of the products. This tied in with other experiences during the study where many people did develop a liking for the products on repeated tasting of them. The solid cheese was generally eaten as a snack on crackers or bread, and the spread was eaten on toast for breakfast.

The products in their present form could be sold as a snack or dessert cheese. This would require a strong marketing effort since these products are unfamiliar to most consumers. However, the relatively high percentage of people rating the products in the dislike categories, suggested that further modification is necessary to increase the acceptability of the products to a greater number of consumers.

Since the spread was found to be preferable, one such modified product could be a spread to which additional appropriate flavourings could be added. The more definite flavouring should also help to dilute or mask the salty flavour and aftertaste (which would be costly to reduce by other methods e.g. demineralization by electrodialysis or ion exchange).

A change in colour might also increase acceptability e.g. a lighter

colour which could be achieved by reducing the amount of browning which occurs.

The results of the survey were sufficiently encouraging for further work on product development of a spread product to be carried out, based on the findings from the survey.

A note of caution is added here that these results may not be directly applicable to Canada as a whole because the population of Edmonton likely has proportionately more people with a variety of ethnic origins than the rest of the country, but it is felt that it still serves as a reasonable guide to the acceptability of these products in Canada.

CHAPTER V

PRODUCT DEVELOPMENT

A. INTRODUCTION

Consideration of the findings of the consumer survey led to the idea of the development of a spread from cottage cheese whey.

The first stage of the work was to establish an optimum range for composition in terms of % solids, % fat, and pH, to give a generally palatable product with bland flavour and good spreadibility. This was initially based on personal judgment, but was to be confirmed by the use of taste panel evaluations.

The effect of variations in the composition on the achievement of a good, smooth texture with no detectable lactose crystals in the spread, was observed through the use of a semi-trained taste panel, attempting to correlate this with the average size of lactose crystals in the product.

In addition, the effect of enzymatic hydrolysis in the whey in reducing the likelihood of sandiness in the products was investigated, and also its effect in sweetening the product.

Once a prototype product was formulated, several flavours were tried to give acceptable final products, and these were subjected to a small-scale consumer panel evaluation to gain an idea of their acceptability.

B. MATERIALS AND METHODS

1. Source of materials

Condensed cottage cheese whey - Cottage cheese whey was obtained from Lucerne Dairy, Edmonton. It was condensed in a single-stage vacuum evaporator (supplied by Arthur Harris & Co., Chicago, Illinois, 1959), at a temperature

of less than 130°F and a vacuum of approximately 24" Hg, to a 45-55% solids concentrate. The concentrate was stored at 4°C and used as the basic raw material as needed.

Lactose-hydrolysed whey - Cottage cheese whey was neutralized to pH 6.0 with 10M KOH, then Maxilact TG lactase enzyme was added at the rate of 1.76g/70 lb and the mixture was gently agitated at 5°C for 5 days. There was about 15-20% conversion of the lactose to glucose and galactose.

2. Sample Preparation

The spread was made on a batch scale - a 200g sample was the maximum amount of product which could be prepared by the method used. The basic method used was to take sufficient of the condensed cottage cheese whey to give the desired final solids content in the product, neutralise it to the required pH with 10M NaOH, add butteroil to give the correct fat content, and then evaporate the mixture in a 600 ml beaker on a hotplate with magnetic stirrer at maximum heat and speed. Evaporation was continued to a % total solids (TS) reading on an Abbe refractometer which was determined empirically to be a reading approximately 10%TS lower than the desired final total %TS.

The final %TS was found to vary depending on the fat content (See Table 16.)

Table 16

Effect of Fat Content on Final %TS in Spread

Formulation		Condensed Cottage Cheese whey (52% TS)	Butteroil	Water	%TS by refractometer	%TS final
% solids	% fat	g	g	g		
65	5	230	10	-	58	66.0
65	10	212	20	18	55	66.1

Those products with a higher fat content appeared to have a higher rate of evaporation while cooling, and consequently did not have to be evaporated to as high a level of %TS as those of lower fat content.

After reaching the desired total solids content the sample was stirred during cooling in the Hobart mixer (Kitchen-Aid Model K5-A), with the whipper attachment at speed 5 for 10 minutes.

3. Analytical Procedures

Due to the variability which occurs in the manufacturing of the spreads, determination of sample composition was necessary (usually only % solids and % fat were determined). The following tests were used.

Total solids - spread samples were dried in the vacuum oven at 80°C for 20 hours.

Fat content - spread samples were analysed using a Mojonnier method for the determination of fat content in whey cheese as specified by the International Dairy Federation (1970).

Protein content - spread samples were analysed using the microkjedahl procedure as outlined by the Association of Official Agricultural Chemists (1975).

Ash content - spread samples were ashed to constant weght in a muffle furnace at 530°C.

Hydrolysis efficiency was ascertained by measuring the lactose content of the original whey(anthrone method of Fagen et al, 1954) and glucose content in the hydrolysed whey (glucose oxidase test kit, Glucose Reagent Set Code G Cat #7451, supplied by Worthington Biochemical Corp., Freehold N.J.)

4. Taste Panel Evaluations

Investigation of the Development of Sandiness in the Spreads

The following spread formulations were prepared so that the effect of a wide range of composition in terms of % solids, % fat and pH, on the

development of sandiness could be examined.

% solids	% fat	pH
65	5	5
65	5	6
65	10	5
65	10	6
70	5	5
70	5	6
70	10	5
70	10	6

A semi-trained taste panel of 8 people from the Food Science Department was asked to rate the samples according to the degree of graininess present in each i.e. as either smooth (no graininess), slightly grainy, moderately grainy or very grainy (See Appendix 3).

Taste panels evaluations were held the day after preparation of the samples, and thereafter at weekly intervals over a 3 or 4 week period.

Preference for Selected Spread Formulations

Spreads selected from the previous investigation on sandiness to give a wide range of % solids, % fat and pH, were evaluated once only for preference, by the taste panel from the sandiness study. The panel was asked to rate the samples for preference using a 7-point hedonic scale (see Appendix 4).

Acceptability of Flavoured Prototype Products

To obtain some idea of consumer acceptance of the final product, two flavoured prototype products - an onion-flavoured spread served on a plain unsalted cracker, and a sweetened maple-flavoured spread served on toast- were evaluated by members of the public who visited the Food Science Display during Varsity Guest Weekend at the University of Alberta on March 11th, 1978. Participants were asked to rate the two prototype products according to a 9-point hedonic scale (See Appendix 4).

5. Microscopic Observation

As further confirmation of the development of sandiness in the spreads,

the size of the lactose crystals was measured. Samples of the spread were spread thinly on glass slides and photographed through an Olympus phase-contrast light microscope with 400 ASA film at 10x magnification. By comparison with a 2mm scale photographed at the same magnification, measurement of crystal size could be made. The size of the longest crystal side of 20 crystals in 5 fields was measured.

C. RESULTS AND DISCUSSION

1. Basic Spread Composition

In initial preliminary trials with various formulation containing 60-70 %TS, 5, 10, and 20% fat and pH 5.0, 5.5 and 6.0, the best composition in terms of spreadability, mouthfeel and flavour appeared to be-

solids	65-70%
fat	10-20%
pH	5.5-6.0

Products with a solids content lower than 65% solids, tended to be quite grainy, while those with more than 70% solids were too firm and did not spread easily. In regard to fat content those samples with 10-20% fat had a pleasant, creamier flavour and smoother texture than the samples containing 5% fat.

Samples with pH 5.0 were unpleasantly acidic and sour in flavour.

These products differed from the traditional whey cheese spreads in being creamy colour (not tan), and having quite a bland flavour, since very little caramelisation occurred. The texture was softer and more spreadable than the traditional whey spreads also.

2. Factors affecting the Development of Sandiness in the Spreads

One of the major quality considerations in a spread is smoothness of texture. It was noted that some the samples, particularly those of low pH,

developed considerable graininess, with crystals being detectable in the body of the samples and visible on the surface of the products. The pH range examined by Steinsholt, (1972), was 6.0-6.6, however there appeared to be no further information in the literature on the effect of a pH around 5.0, on the development of graininess in this type of product.

An investigation of the effects of %TS, % fat, and pH on the development of sandiness or graininess in the spreads was carried out. Two sets of samples were prepared (See Table 17). The difficulty in obtaining the exact desired total solids content is evident in the first set of samples. A second set was prepared, so that a correct range of formulations could be evaluated.

Table 17

Composition of Samples Used in the Investigation of Sandiness in Spreads

Formulation		pH	Final % solids		Final % fat	
Desired % solids	Desired % fat	of condensed cottage cheese	Set 1.	Set 2	Set 1.	Set 2.
65	5	5	66.0	64.3	5.1	5.1
65	5	6	64.3	63.8	4.9	5.2
65	20	5	71.2	68.5	22.2	20.3
65	20	6	69.7	66.9	20.3	20.8
70	5	5	69.2	67.0	5.2	5.0
70	5	6	68.0	66.6	4.6	5.1
70	20	5	74.5	67.5	20.8	19.2
70	20	6	72.0	66.8	20.1	18.4

The results of the taste panel evaluations over the 4 week period (Fig. 5) show that low pH seems to promote the development of undesirably large lactose crystals in the products, particularly when the fat content is low. High fat content seems to be less important than high pH but appears to have some protective effect in preventing sandiness (this may partly be

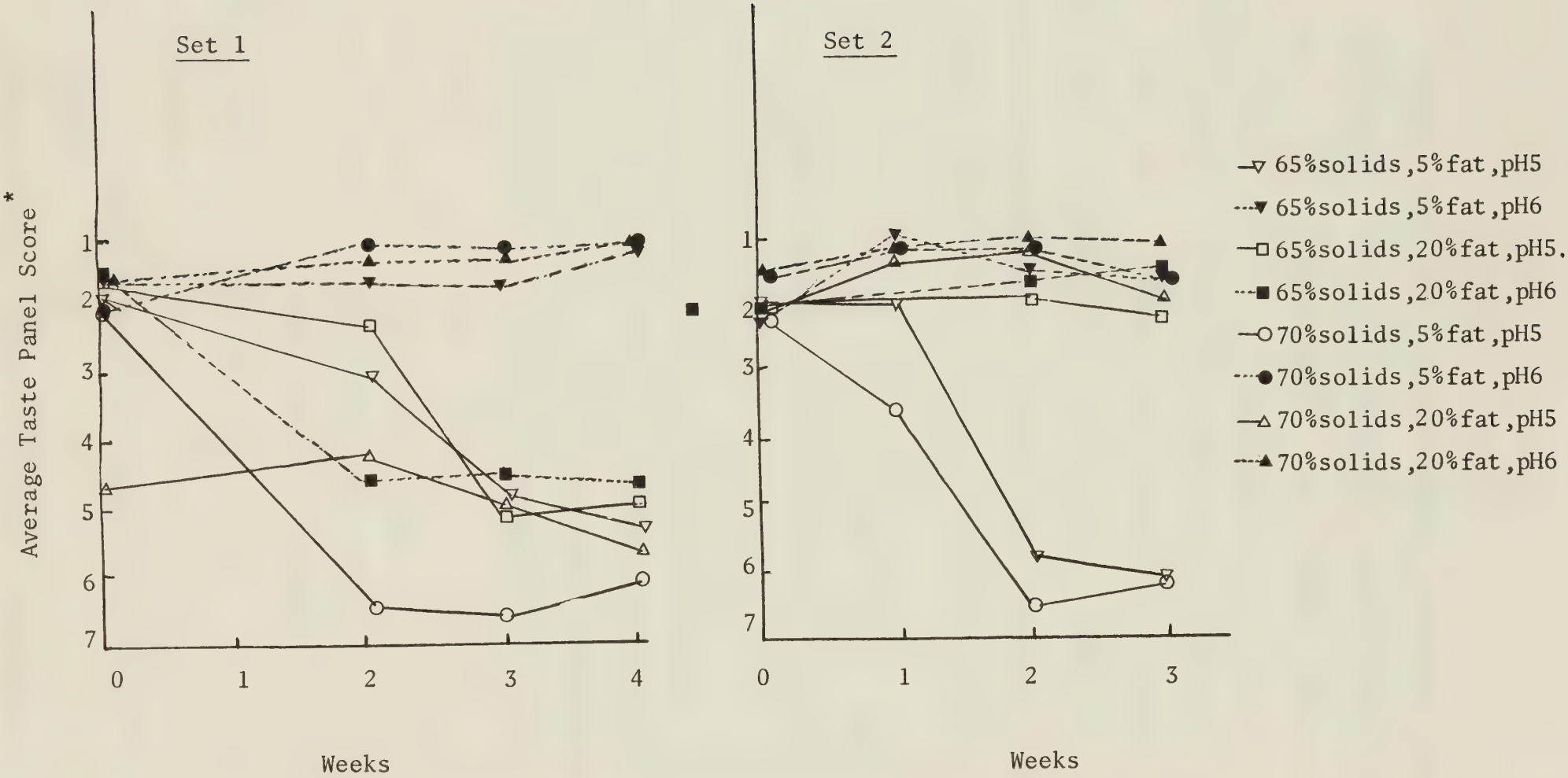


Fig. 5 Results from Taste Panel Study on Lactose Crystallisation

* 7-point scale 1-smooth(no graininess)→7-very grainy

a concentration effect i.e. the higher the fat content the lower the lactose content in the product). However, it was difficult to find any effect of increasing solids content, since the final solids content varied so much.

Both the 65% solids, 20% fat and 70% solids, 20% fat formulations in the first set were quite sandy, but in the second set they were both smooth in texture. The outcome seems to be quite unpredictable, and hard to explain in some cases considering that both sets were prepared using identical procedures.

In the case of the 70% solids, 20% fat, pH 5.0 sample from set 1, which was rated as grainy, the product may have been mistaken as being grainy because of its particularly high solids content which was very hard on the palate.

Two types of graininess were evident. With the 65% solids, 20% fat samples from set 1, which developed graininess, there was a distinct sandiness throughout, whereas with the low pH samples, which were found to be grainy, large crystals were detectable. Microscopic examination of the samples showed that in the 65% solids, 20% fat samples (See Fig. 6) which are very grainy, there are numerous crystals larger than 56μ throughout, which according to Frennborn (1959), are sufficient for a spread-type product to be considered sandy. In the case of low pH samples however, crystals of this size are not evident (See Fig.7), and it is suspected that agglomerates of crystals may be formed which were broken up on spreading the samples on the glass slide for examination. A sample of a spread which was considered to be smooth by the taste panel, is shown for comparison (See Fig 8).

There did not appear to be any correlation between measurements of the average size of the longest lactose crystal edge and the development of sandiness in the spreads.

Generally speaking, the development of large lactose crystals seemed to be

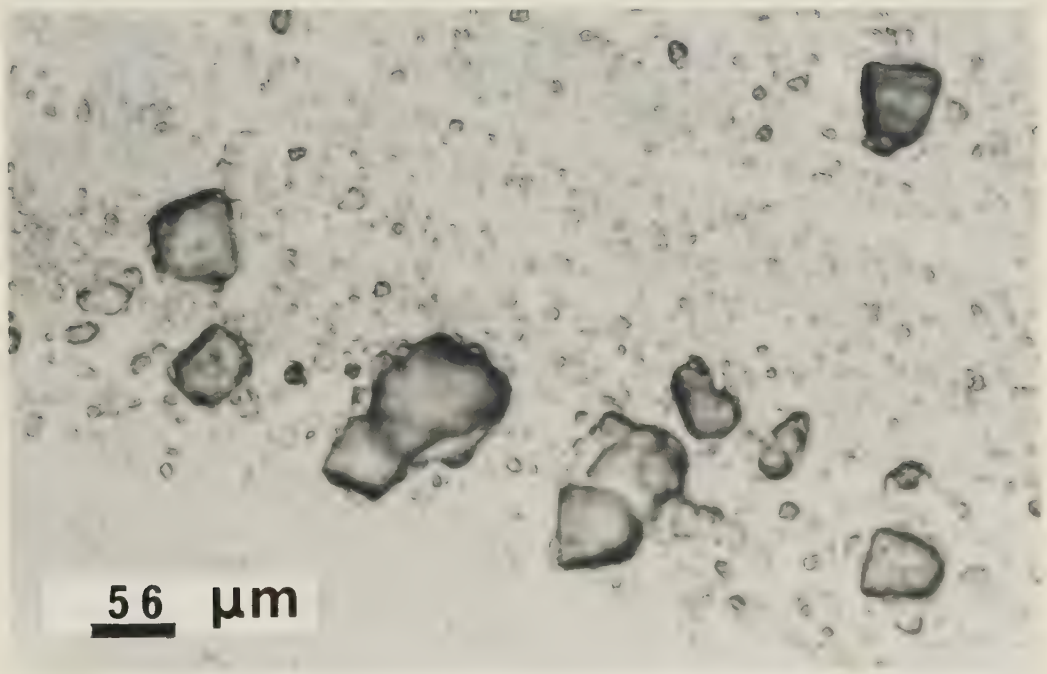


Fig. 6 Whey Spread Sample Rated by Taste Panel as Being Grainy Throughout. Set 1. 70% solids, 5% fat, pH 6.0. After 3 weeks.

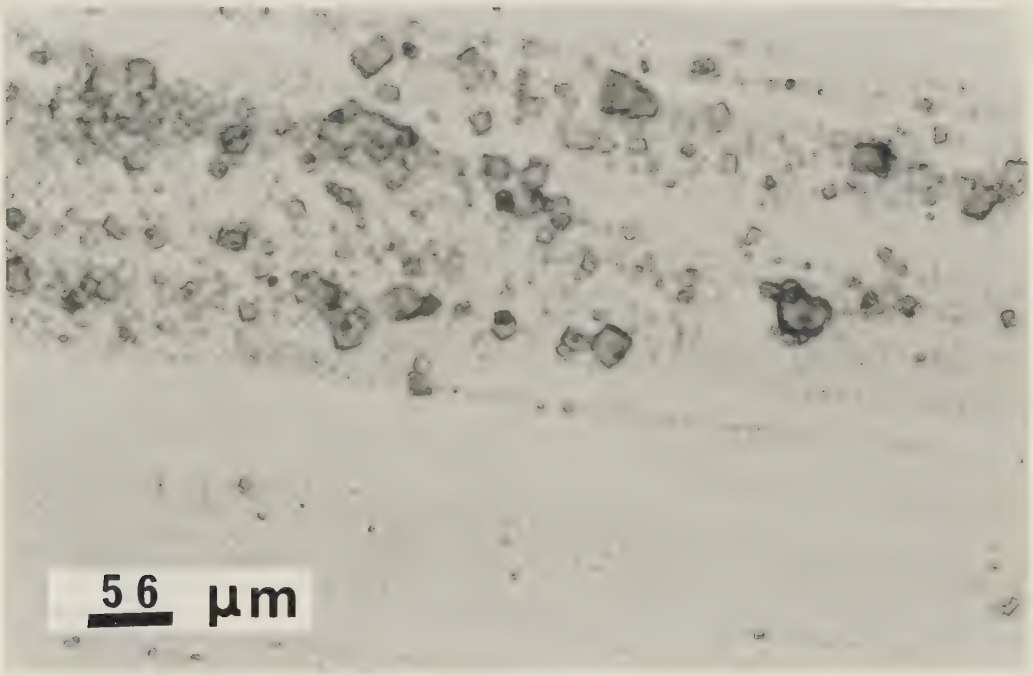


Fig. 7 Whey Spread Sample Rated by Taste Panel as Having Occasional Large Grains. Set 2. 70% solids, 5% fat, pH 6.0. After 2 weeks.

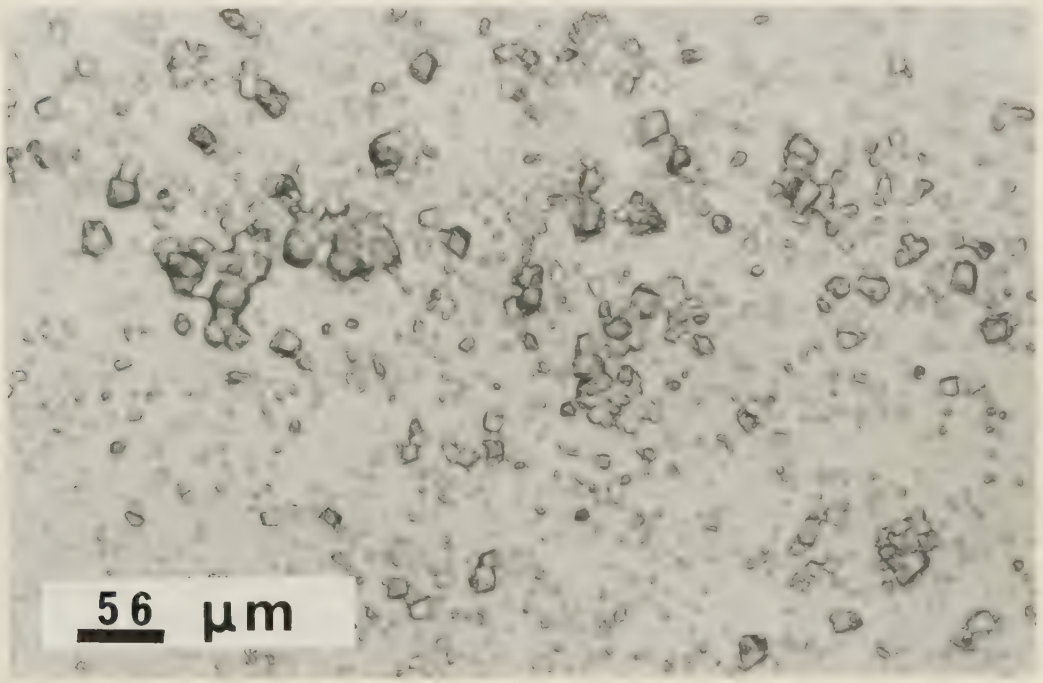


Fig. 8 Whey Spread Sample Rated by Taste Panel as Having a Smooth Texture. Set 2. 70% solids, 20% fat, pH 5.0. After 2 weeks.

avoided by higher pH and fat content in the spreads.

Spread from Lactose-hydrolysed Whey - Preliminary work has shown that a product of 70% solids, 20% fat formulation prepared from a 45% solids concentrate of lactose-hydrolysed whey (15-20% conversion), had a much softer texture, a translucent darker tan appearance (closer to the appearance of the traditional whey spreads) and interesting caramel flavour, though detectable lactose crystals were still present. Presumably the degree of hydrolysis was insufficient to prevent lactose cyrstallisation because Bouvy (1974), maintains that only 20-30% of lactose needs to be hydrolysed in condensed whey syrup to prevent crystallisation of lactose.

3. Acceptance Panel on Selected Samples

In order to determine the acceptability of the samples, a preference panel was conducted on selected samples from the previous study on sandiness. The samples, all of which had a smooth texture, were chosen to give a representative range of composition in terms of % solids, % fat and pH.

The results (See Table 18) indicated that the samples with the higher pH i.e. 6.0, were significantly preferred for spreadability and flavour. From the comments it was clear that those with higher fat content (i.e. 20%) were preferred, though this was not statistically significant.

These trends were in line with the findings in the study on sandiness in the spreads, in which the samples with higher pH and fat content were unlikely to show problems with an unacceptable degree of lactose crystallisation.

The use of cottage cheese whey, if it is first neutralised, seems to give a reasonable spread product. The results are similar to those found by Steinsholt et al (1965), and Steinsholt (1972) in their investi-

Table 18

Acceptance of Selected Spread Formulations

Formulation			Final % of solids	Average Taste Panel Score *
% solids	% fat	pH		
65	5	6	63.8	3.7
65	20	5	68.5	6.0 * *
65	20	6	66.9	3.3
70	5	6	66.6	3.7
70	20	5	67.5	6.2 * *
70	20	6	68.8	2.9

* 7-point hedonic scale 1-excellent → 7-poor

* * sig. worse at $p \leq .05$ by the non-parametric ranking method of Kramer et al (1974).

gation into the quality of mysost, in that increasing fat content and pH result in a more pleasant tasting product. The effect of increasing % nitrogen, by the addition of increasing amounts of cream/milk in the formulation on improving the flavour of the product was not studied, but may also be advantageous in this spread product.

4. Acceptability of Flavoured Prototype Products

From the preference panel it was decided that the prototype formulation would be 70% solids and 20% fat.

Two flavoured prototype products were made as shown in Table 19 (See Fig. 9).

Onion-Flavoured Spread - envisaged as a savoury spread for crackers, somewhat like a spreadable savoury cheese or dip. It was flavoured with onion as this is a popular dip flavour.

Maple-Flavoured Spread - a sweetened product which was considered to be a breakfast spread for toast - 'whey honey' so to speak.

The samples were evaluated by 43 members of the public who visited the Food Science Display during Varsity Guest Weekend, March 11th, 1978. Both products appeared to be quite acceptable (See Table 20)-the onion spread somewhat more so, largely on account of its flavour.

There was a problem of sandiness in the final products despite using the best processing method determined, as several people commented on grittiness.

Also many of the tasters felt that the spreadability could be improved. There was a certain crumbliness of texture evident in the samples, though the panelists from the previous preference panel had not commented on it. It may be speculated that the crumbliness in texture is due to the high proportion of whey solids present (which might be improved by increasing

Table 19

Composition of Flavoured Prototype Products

Product	Formulation				Composition			
	% solids	% fat	% sucrose	flavouring	% solids	% fat	% protein	% ash
Onion-Flavoured Spread	70	20	--	½ tsp. onion powder	72.3	20.6	6.7	7.2
Maple-Flavoured Spread	70	20	10	3 drops maple flavour	70.3	20.5	6.7	5.4

Fig. 9 Flavoured Protoype Products and Spread from Lactose-Hydrolysed Whey.

A Onion-flavoured Spread

B Sweetened Maple-flavoured Spread

C Spread from Lactose-Hydrolysed Whey.

Table 20

Acceptability of Flavoured Prototype Products

Product	Average Score *			
	Appearance	Flavour	Texture	Overall
Onion-Flavoured Spread	6.8	7.9	6.9	7.6
Maple-Flavoured Spread	6.8	6.3	6.5	6.6

* Average of 26 evaluations for each product, rated on a 9-point hedonic scale 9 especially well-liked → 1 especially disliked

the protein content of the spread) or to denaturation and loss of water-binding capacity of the proteins at the neutralised pH 6.0 or even crystallising of the butteroil (in which case it would be better to use cream).

The uneven appearance of the samples giving the impression of bubbles on the surface of the spread, was not liked by the tasters. This may have been due to the use of the whipping attachment rather than the flat blade of the Hobart mixer during the mixing/cooling stage.

5. Conclusions

It was found that a reasonably satisfactory spread product could be produced from cottage cheese whey, providing it was first neutralised to pH 6.0. Using the batch method of production established, the optimum composition of the spread appeared to be 65-70% solids, 20% fat, and pH 6.0, in terms of good spreadability , mouthfeel, and flavour, as well as being able to avoid sandiness in the product. The product had a cream colour and a bland, creamy flavour.

Two flavoured prototype products which were evaluated had good acceptability. An onion-flavoured spread (70% solids, 20% fat) may be suitable as a snack product to be spread on crackers. A sweeter spread made with the addition of sucrose or from hydrolysed whey also appears to be acceptable as a breakfast spread, though perhaps with a different kind of flavour e.g. caramel.

Since lactose crystallisation still appears to present some problem in these products, it should be further studied in any scale-up experiments which may be carried out. Based on the work of Hunziker (1949), it is thought necessary to hold the product in the area of maximum

crystallisation (as determined by % lactose-in-water in the product) for a suitable length of time to encourage the development of many small lactose crystals, so that most of the lactose is crystallized and it is not so likely that these will be able to later grow, and give rise to objectionable sandiness in the product (Frennborn, 1959). Due to technical difficulties, the rate of cooling in these small batches was not studied, but is thought to be the most important factor in the development of lactose crystals in the product. It is possible that the use of emulsifiers or vegetable gums may be useful in helping to prevent lactose crystallisation (the latter is used in the ice-cream industry to prevent sandiness). The product made from lactose-hydrolysed whey was not satisfactory in that it was very grainy, too. Further studies on the hydrolysis of whey are needed to ensure that graininess in this type of product is avoided too.

CHAPTER 6

CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

Results from a consumer survey showed limited acceptability for a commercial Swedish whey cheese and spread. These products may be possibilities for marketing in Canada, but would require a vigorous marketing effort to bring them to the awareness of most people. However, the response from the survey was promising enough for further product development work to be carried out in producing a modified spread product.

In the product development work, samples of spread were prepared by evaporating neutralised cottage cheese whey and butteroil. The effect of a range of solids contents (65-70%), fat contents (5-20%) and pH values (5.0-6.0) in the product were examined. Products with the higher pH (6.0) had a much more acceptable flavour, and usually a smooth texture. Those with pH 5.0 were unpleasantly acid in flavour and low pH (5.0) was generally related to sandiness in the samples. Higher fat content (20%) and to a lesser extent higher solids content (70%) appeared to lessen the likelihood of the development of sandiness in the products, and also resulted in a better spreadable consistency and creamier flavour.

The prototype formulation decided on was 70% solids, 20% fat and pH 6.0. This product had a cream colour and fairly bland creamy flavour, since very little of the caramelisation which is typical of the traditional whey cheese and spreads occurred in the process used.

Two flavoured prototype products (i) an onion-flavoured spread and (ii) a sweetened maple-flavoured spread had good acceptability. A spread product prepared from lactose-hydrolysed whey had an interesting soft texture and caramel flavour, but still showed problems with sandiness.

Suggestions for further work

1. Improve and/or scale-up the method in order to produce samples under conditions closer to those which would be encountered on an industrial scale so that problems such as that of sandiness in the product could be monitored more easily, particularly in respect to controlled cooling conditions which seem to be of critical importance.
2. Addition of gums (and possibly emulsifiers) to help prevent sandiness in the product.
3. Increase the protein content, through the addition of milk/cream, skim milk powder or whey protein concentrates, in order to improve the texture and flavour of the products.
4. Investigation of the effect of demineralisation and ultrafiltration in reducing the effect of the high ash content of cottage cheese whey (compared to cottage cheese whey) and that added in the neutralisation step, on flavour.
5. Further investigation of the lactose hydrolysis to produce sweetened spreads - optimise the level of hydrolysis necessary to produce a smooth texture.
6. Experimentation with other flavours in the spreads e. g. caramel.
7. Preliminary costing studies could be carried out.

Generally, the prototype products did show promise and as long as future research is able to prvide solutions to the sandiness problem in texture, they could be a useful means of utilising whey in Alberta. A good deal of marketing effort would still be required, but it is proposed that they would be more acceptable to Canadian consumers than the traditional whey cheese products.

REFERENCES

Association of Offical Agricultural Chemists. 1975. "Official Methods of Analysis" 11th ed. Washington D.C.

Bergum, A.T. 1950. Undersolkelser over melkesukkerets krystallisasjon i mysost (Investigations on the crystallisation of lactose in whey cheese). Beretning Statens Meieriforsok (Norg.LandbrHogsk) 41: 54 pp.

Bergum, A.T. and Nilsen, A. 1950. Forsok med inndamping av melk og myse under vakuum (Experiments on the evaporation of milk and whey under vacuum). Beretning Statens Meieriforsok (Norg.LandbrHogsk) 43:62 pp.

Bouvy, F.A.M. 1974. Whey production and utilisation in Europe; Applications of lactase-treated whey and other dairy proudcts. In Proc. Whey Products Conference, Illinois.

Better Homes and Gardens Publication. 1966. "Cooking with Cheese." Meredith Press, N.Y.

Byre, O. and Staxrud, K.M. 1967. Noen undersokelser over utbytteforholdene og arbeidsbehovet ved produksjonen av mager mysost (Studies on yield and labour requirements in the manufacture of cheese from skimmed whey). Meieriposten 56: 616-622, 635-645, 661-665.

Davis, J.G. 1976. "Cheese. Volume III. Manufacturing Methods." Churchill Livingstone, Edinburgh.

Economics Division, Alberta Department of Agriculture. ca. 1973. An Economic Feasibility Study of the Use of Reverse Osmosis and Ultrafiltration for Cheese Whey Disposal in the Edmonton Area.

Emmons, D.B., Modler, H.W. and Holme, J. 1974. Whey processing - some economic aspects. In Proc. of Whey Utilisation Symposium, Canada Department of Agriculture, Ottawa.

Emory, W. 1976. "Business Research Methods." Richard D. Irwin Inc. Illinois.

Fagen, H.J., Sibbach, E. and Hussong, R.V. 1954. The use of anthrone for the quantative estimation of lactose in dairy products. J. Dairy Sci. 37: 10

Frennborn, T. 1959. A method to avoid sandy consistency in some whey cheese products In Proc. Intl. Dairy Cong. 2: 1231.

Fresnel, J.M. 1978. Swiss scientists develop soft drink from whey. Food Prod. Dev. 12: 45.

Gillies, M.T. 1974. "Whey Processing and Utilisation. Economic and Technical Aspects." Noyes Data Corp., N.J.

Hansen, R. 1959. Ein neuer Einstrom-Nachverdampfer Zurdontinuierlichen Herstellungvon "Braunkase", Norwegischem Molkenkase, und zur Eindamfung von Molke fur Futterungszwecke (A new one-flow evaporator for the continuous manufacture of "brown cheese", Norwegian whey cheese, and for the evaporation of whey for feeding purposes). Milchwissenschaft 14: 581.

Holsinger, V.H. 1972. The use of cheese whey in beverages. In Proc. Whey Products Conference, Illinois.

Hunziker, O.F. 1949. "Condensed Milk and Milk Powder." Published by the author. Illinois.

International Dairy Federation. 1970. Determination of the fat content of whey cheese. International Standard FIL-IDF 59.

Jelen, P. and Buchheim, W. 1976. Norwegian whey "cheese". Food Technol. 30: 62.

Jelen, P. and LeMaguer, M. 1976. Feasibility evaluation of cheese whey processing in small plants. J. Dairy Sci. 59: 1347.

Jelen, P. and McIntyre, D. 1977. Sensory evaluation of meat products containing coagulated cheese whey lactalbumin. J. Food Sci. 42: 281.

Kjell, S. 1955. Undersokning av mikrofloran i svenska mesvaror och dess betydelse for kvaliteten (The microflora of Swedish whey products and the effect on quality). Mejeritek Medd. 16: 69.

Kosikowski, F. 1970. "Cheese and Fermented Milk Foods," p. 279. Edward Bros. Ann Arbor, Mich.

Kramer, A., Kahan, G., Cooper, D. and Papavasiliou, A. 1974. A non-parametric ranking method for the statistical evaluation of sensory data. Chem. Senses & Flavor 1:121.

Lebedeva, K. and Mironov, A. 1961. New whey product - cheese paste. Mol. Prom. 22: 15.

Lowrie, R. 1978. Personal communication.

Modler, H.W. 1974. Alternative methods of processing whey. In Proc. of Whey Utilisation Symposium, Canada Department of Agriculture, Ottawa.

Modler, H.W., Emmons, D.B. and Savage, K.G. 1973. Integrated nationwide

approach needed to solve whey disposal problem in Canada. Modern Dairy 52: 14.

Mork, I., Nilsen, A. and Aasaren, O. 1948. Forsok med maskinell forming av blandet geitmysost (Experiments on mechanical molding and wrapping of goat's whey cheese). Beretning Statens Meieriforsok (Norg. LandbrHogsk) 39: 1-29.

Oborn, J. 1968. A review of methods available for whey utilisation in Australia. Aust. J. Dairy Technol. 23: 131.

Oterholm, O. and Sodal, E. 1959. Bakteriologiske undersokelser vedrorende produksjon av brunost (Bacteriological studies concerning the manufactureof whey cheese). Meieriposten 48: 971-979, 999-1001, 1019-1024, 1043-1049.

Palmer, G.M. and Marquadt, R.F. 1978. Modern technology transforms whey into wine, Food Prod. Dev. 12: 31.

Sauge, P. 1960. Fra en undersokelse av utstyr for framstilling av brunost (An experiment on the equipment for the manufacture of whey cheese). Meieriposten 49: 429-432, 473-475.

Sauge, P. 1961. En teknisk og okonomisk undersokelse av moderne utstyr for framstilling av brunost (A technical and economical investigation for the production of whey cheese). Meieriposten 50: 41, 77, 103, 122.

Signerne, A. 1954. Orientering om den nye brunogryten "Gryta" (Information about the new whey cheese kettle "Gryta"). Meieriposten 43: 303.

Sihlbom, E. 1957. Mesvaror (Whey products). Var foda 9:13.

Sinnamon, H.I. 1974. The heat coagulation of cottage cheese whey proteins and their incorporation into macaroni. In Proc. Whey Products Conference. Illinois.

Skaltveit, T. and Sorbo, S. 1956. Orienterende praktiske forsok ved bruk av O.B.M.-osteroremaskinen (Practical experiments with the OBM cheese stirring machine). Meieriposten 45: 923.

Solberg, P. 1953. Utilisation of by-products. In Proc. 13th Intl. Dairy Cong. 2: 693.

Steinsholt, K. 1972. Virkningen av geitmelk fra forste og siste maned i laktasjonperioden, blandingsprosent, henstand av konsentratet og ostens oppbevarings-temperatur det forste dognet pa kvaliteten av gudbrandalsost, G35 (The effect of goatmilk from the first and last month of the lactation period, the percentage of milk and cream, storage temperature of the cheese the first 24 hours, upon the quality of gudbrandalsost, G35). Meieriposten 61: 643.

Steinsholt, K., Byre, O. and Ystgaard, O.M. 1965. Fremstilling av flotemysost F33. I. Virkningen av myselag,blandinsprosent og pH i mysa med hensyn pa ostens kjemiske og organoleptiske kvalitetsengenskaper (Manufacture of cream mysost F33. I. Effect of type of whey, cream/milk ratio, and pH of whey on chemical and organoleptic characteristics). Meld. Meieriinst. Report No. 121.

Steinsholt, K. and Ystgaard, O.M. 1966. Fremstilling av flote-mysost F33 II. Sammenhengen mellom ostens kvalitetseg-enskaper og den kjemiske sammensetningen av osten, mysa og mysebehandling.(Production of cream mysost F33. II. The relationship between the quality characteristics of the cheese and the chemical composition of the cheese, the whey and the mixture of whey, cream and milk). Meld. Meieriinst. Report No. 123.

Sundt, J. 1976. Statistics from Norwegian Dairy Sales Association by personal communication.

True, L.C. and Patel, C.C. 1973. Recovered ricotta cheese from whey acceptable as snack dip base. Food Prod. Dev. 7: 72.

Vik, A. and Hedland, G. 1956. Noytralisering av myse og mysekonsentrat for brunostproduksjon (Neutralisation of whey and whey concentrate for whey cheese manufacture). Meieriposten 45: 149-154, 175-180, 192-198, 218-223.

Webb, B.H., Johnson, A.H. and Alford, J.A. 1974. "Fundamentals of Dairy Chemistry." The Avi Publishing Co. Inc., Westport, Connecticut.

Appendix 1. Form used in New Dairy Product Survey

Food Science Department
University of Alberta.

NEW DAIRY PRODUCT SURVEY

As part of a research project in the Food Science Department at the University of Alberta, we are trying to determine the acceptability of these two dairy products you have been given - a type of dairy product (commercially produced) and a spread made from it, which is very popular in Norway.

The solid product (which is very thinly sliced) and the spread, are usually eaten on rye bread, crispbreads or crackers.

Could you please try the samples in any way they may appeal to you, and then answer the following questions about them.

Please return the questionnaires in the stamped addressed envelope preferably no later than October 25th.

1. When did you eat the samples you have been given?

	Solid	Spread
Breakfast	☐	☐
Lunch	☐	☐
Supper	☐	☐
Snack	☐	☐

2. How did you eat the samples:

			Solid	Spread
(a)	Alone	on regular white/brown bread	☐	☐
		on toast	☐	☐
		on crispbread/crackers	☐	☐
		other	____	____
			Solid	Spread
(b)	With other foods	on bread	☐	☐
		toast	☐	☐
		crackers	☐	☐

What did you combine them with? _____

_____

(c) In other ways - e.g. cooking or baking: _____

_____

_____

_____

Please turn over

3. Would you buy either of these products if they were available at a reasonable price?

	Solid	Spread
Often	☐	☐
Sometimes	☐	☐
Never	☐	☐

4. What is you opinion of these products?
(Fill in an answer for each member of the household. Mark the opinion which applies in the space provided).

Opinion

A. Like very much
B. Like moderately
C. Like slightly
D. Dislike slightly
E. Dislike moderately
F. Dislike very much

Member of Household	Age*	Opinion Solid	Opinion Spread	Comments
Example:	16	C (from above list)	D	e.g. about flavour or texture
1	____	____	____	_____
2	____	____	____	_____
3	____	____	____	_____
4	____	____	____	_____
5	____	____	____	_____
6	____	____	____	_____
7	____	____	____	_____
8	____	____	____	_____
9	____	____	____	_____
10	____	____	____	_____

*Optional, but we are interested in whether particular age groups like these samples.

5. Have you ever eaten this type of dairy product before: Yes ☐ No ☐
If yes, (a) Where did you try it? _____
(b) How often did you eat it? _____

6. What is your ethnic background? Scandanavian ☐ Other ☐

For further information about the survey contact: D. McIntyre: 432-4590

Appendix 2. Supplementary Housewife Taste Panel Form

ACCEPTABILITY TESTING

This test is being conducted to learn how much you like or dislike each sample offered.

Please use the following 9 point scale to indicate your opinion of the appearance, flavour, texture, and overall quality of each sample:

9. especially well liked
8. liked very well
7. liked moderately
6. like slightly
5. neither liked nor disliked
4. disliked slightly
3. disliked moderately
2. disliked very much
1. especially disliked

Please also add comments in the space provided to indicate characteristics you particulary liked or disliked in each sample.

SAMPLE NO.						
APPEARANCE						
FLAVOUR						
TEXTURE						
OVERALL QUALITY						
COMMENTS						

Appendix 3. Taste Panel Form Used in Graininess Study

DAIRY SPREAD TEXTURE PANEL

Name _____ Date _____

This project involves the development of a dairy spread. One of the main requirements in this work is the achievement of a smooth, spreadable texture.

At present, I am investigating the influence of several factors on the development of graininess in the spread.

Please taste the samples provided and rate them according to the degree of graininess present in each. Write any additional comments in the space provided.

Sample No.							
Smooth (no graininess)							
Slightly Grainy							
Moderately Grainy							
Very Grainy							

COMMENTS:

Thank you.

Appendix 4. Taste Panel Form Used in Preference Panel on Selected Samples and Flavoured Prototype Products

DAIRY SPREAD TASTE PANEL

Name _____ Date _____

Please taste these samples of dairy spread and mark your overall opinion of each of the samples.

Please also add comments in the spaces provided to indicate characteristics you particularly liked or disliked in each sample.

Sample No.						
Like very much						
Like moderately						
Like slightly						
Neither like nor dislike						
Dislike slightly						
Dislike moderately						
Dislike very much						

Comments: